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(12) (19) (CA) **Demande-Application**

(21) (A1) **2,244,610**
(22) 1998/07/31
(43) 1999/02/11

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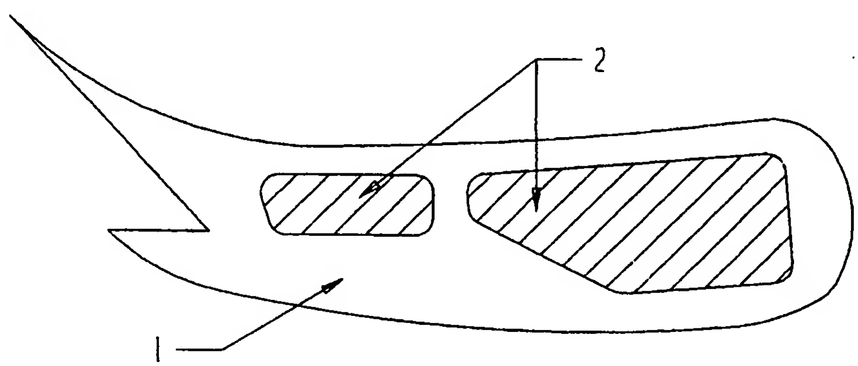
(51) Int.Cl.^{6} A63B 59/14
(30) 1997/08/11 (08/909,126) US

(54) **LAME POUR BATON DE HOCKEY ET METHODE POUR SA FABRICATION**

(54) **CROSSOVER HOCKEY BLADE AND METHOD**



(57) La présente invention a pour objet une lame de bâton de hockey fabriquée d'un matériau composite destinée au hockey sur glace et autres surfaces; une méthode pour la fabrication de ce type de lame est également visée par les présentes. La lame en question combine les caractéristiques suivantes : poids léger, haute résistance à la rupture, haut degré de rigidité (hockey sur glace) et haute résistance à l'usure (hockey sur surfaces autres que la glace). La lame elle-même est composée d'une âme en matériau polymère résistant à l'usure et d'inserts en mousse structurée de plus faible densité placée en sandwich dans une structure composite incorporant des laminés de résine renforcés de carbone ou de fibre de verre ajoutant résistance et rigidité à la lame. La lame peut incorporer un raccord léger, à haute résistance et de rigidité élevée pour accroître la force et le rendement du joint entre la lame et le bâton.

(57) The invention consists of a composite material hockey stick blade suitable for use in both ice and off-ice hockey, and of a method for producing this type of blade. The blade combines the light weight, high breaking strength and high degree of stiffness needed for an ice hockey stick with the high wear resistance required for an off-ice blade. The blade itself is made up of a wear resistant polymeric core with lower density inserts of structural foam sandwiched in a composite structure incorporating carbon and/or fiberglass reinforced resin laminates to provide the strength and stiffness to the component. The blade can incorporate a high strength, high stiffness, lightweight hosel to improve the strength and performance of the blade to shaft joint.

ABSTRACT

The invention consists of a composite material hockey stick blade suitable for use in both ice and off-ice hockey, and of a method for producing this type of blade. The blade combines the light weight, high breaking strength and high degree of stiffness needed for an ice hockey stick with the high wear resistance required for an off-ice blade. The blade itself is made up of a wear resistant polymeric core with lower density inserts of structural foam sandwiched in a composite structure incorporating carbon and/or fiberglass reinforced resin laminates to provide the strength and stiffness to the component. The blade can incorporate a high strength, high stiffness, lightweight hosel to improve the strength and performance of the blade to shaft joint.

CROSSOVER HOCKEY BLADE AND METHOD

The present invention relates generally to hockey stick blades and their manufacturing, more particularly, to blades made of composite materials which are suitable for use in both ice and off-ice hockey.

BACKGROUND OF THE INVENTION

Traditionally, hockey sticks for use in ice hockey have been made of selected woods with careful attention paid to the quality and orientation of the wood grain for each of the stick components. Developments to improve the stiffness and strength of the stick have included improved quality control of the woods used, lamination of the shafts and the bonding of glass, carbon and other fibers to the exterior faces of the shaft and the blade. More recently, in an attempt to obtain strong, stiff sticks with reduced weight, hollow shafts of aluminum, composite and hybrids of aluminum and composite have been developed. Separate, replaceable fiber reinforced wooden blades or composite blades are inserted into these shafts to form a stick. These developments have been effective in improving stiffness and strength but have resulted in increasingly expensive hockey sticks.

Hockey sticks for off-ice (in-line and road) hockey typically use wear resistant acyrlonitrile butadiene styrene (ABS) blades. These blades are relatively heavy and flexible and are not considered suitable for ice hockey although they are extremely wear resistant and thus suitable for off-ice hockey.

All composite construction ice hockey blades can be stiffer, stronger and lighter than conventional wooden blades used in ice hockey, as well as road hockey blades made of ABS. For example, a composite blade made of a glass and graphite epoxy skinned polyurethane sandwich panel can weigh as low as 160 grams and have stiffness as high as 75 kN/M while a high performance wood blade with graphite reinforcement weighs 185 grams with a stiffness of 43 kN/M. The lighter, stiffer composite blade provides the hockey player with a tool that can generate greater shot accuracy. However, it is not sufficiently wear resistant for off-ice

hockey usage.

A search of the patent literature relating to hockey sticks revealed a number of patents on blade technology. Most of these are not closely relevant to the teachings of the current invention in that they concern only improvements in standard laminated wood or fiberglass reinforced wood blades. These improvements include various tongue and groove connection mechanisms between the blade and a wooden shaft and morphology changes such as varying the degree of curvature of the blade.

Canadian Patent Application 2,099,853 discloses a method for manufacturing a composite blade by injection molding while using a foaming agent mixed with the resin to make a foam core. It is clear from the claims that short fibers, rather than continuous fibers, are used in this process, being mixed with and injected into the mold with the resin. It is well established that short fiber reinforced composites have only a small percentage of the strength and stiffness of the continuous fiber reinforcements that are used in the current invention. The blade revealed by this application will have far inferior stiffness, strength, weight and wear resistance than the current invention.

Canadian Patent 1,063,747 discloses a composite reinforced blade structure for a hockey stick. The composite blade consists of a foam core surrounded by a glass fiber reinforced plastic skin. The blade is formed in one piece, and the shaft is then inserted into this cavity and secured by an adhesive. The adhesive joint bonding the shaft to the blade will be much weaker than the joint of the present invention. The core is a syntactic foam with high impact resistance, but these foams are not wear resistant as is the core of the present invention, thus this blade would not be suitable for off-ice use and have therefore not met commercial success.

United States Patent 4,059,269 teaches a blade with the core consisting of a single piece of wear resistant material, such as ABS plastic, with the wear resistant core exposed below, above and to the front of the fiber reinforced resin layers which stiffen and strengthen the blade laterally. The use of a wear resistant polymeric core such as ABS plastic to provide wear

resistance at the bottom of the blade is similar to the concept of the present invention. Experience with the art has shown that blades of this kind are much heavier than the current invention because a solid ABS type core is used rather than one with a significant percentage of its cross sectional area replaced with much lighter foam inserts. This blade would be suitable for off-ice hockey but would not possess the light weight, stiffness and joint strength required for a high performance ice hockey stick.

United States Patent 4,124,208 discloses a one piece stick with a foam filled honeycomb core and metal skins on both blade and shaft, which would be a wear resistant stick but would be very expensive to produce, and thus is not surprising that it has not been made commercially available.

United States Patent 4,134,587 reveals an ice hockey stick with a wear resistant heel on the blade comprising a strip of epoxy resin. This strip of epoxy would indeed provide some wear resistance in the heel area of this stick, although it is not an integral part of the core but is described as bonded to the lower edge of the heel portion it would be subject to impact damage and removal. In any case, the invention comprises the addition of a wear resistant epoxy layer on the heel of an otherwise conventional stick consisting of a wood shaft and blade reinforced with fiberglass sheets which cannot be considered, at this juncture, a high performance stick for ice hockey use because of its high weight and low stiffness compared to composite sticks.

United States Patent 5,332,212 reveals a hockey stick blade coated with an elastomeric polymer such as polychloroprene to provide improvements in feel, adhesion of the puck to the blade, resiliency, water absorption, wear, and reparability. The use of elastomeric coatings and polymers for abrasive wear reduction is wide spread and has been practiced for several decades. Applications in common practice include use for bearings, gears, seals, piston rings, flooring materials and dental restoratives.

United States Patent 5,333,857 teaches an all composite stick with a foam sandwich core blade. This is representative of a number of commercially available composite sticks

which differ only in the specific core materials and fiber geometry specified in the patents or used in commercial production. This type of stick is expensive and suitable for ice hockey but is not sufficiently wear resistant to be suitable for off-ice hockey. Nor does this patent specifically address the problem of failures at the shaft to blade joint as does the present invention.

United States Patent 5,496,027 is based on the use of a braided or tubular fiber reinforced resin sleeve molded in place over a standard wooden replacement hockey stick blade including the connection end at the top of the replacement blade. This is claimed to reduce breakage at the point of connection. This use of fiber reinforcement over a wooden blade and connection point does not result in a strong joint between the hosel and the blade as does the present invention nor does it result in a wear resistant stick suitable for off ice play. Once the composite layer is abraded away by the road or concrete rink surface the wooden core will wear swiftly away. This is the underlying reason why ABS polymeric blades have superseded wooden blades for off-ice hockey in practice.

Experience reveals that 69% of all hockey stick failures occur in the blade (25%) or at the junction of the blade and the shaft (44%). Only 31% occur in the shaft itself. Experience has also shown that wood blades, whether reinforced with fiber or not, are not sufficiently wear resistant for off-ice hockey thus they have been superseded by ABS blades and fiber reinforced ABS blades. These blades tend to be much heavier than high performance blades used for ice hockey.

Table 1 compares some of the critical parameters of the performance requirements of current ice hockey blades versus off-ice hockey blades that are either commercially available or that have been extrapolated from the patent literature by experienced engineers. The weights are expressed in grams and reflect the state of the art circa 1997, although it is projected that weights will continue their downward trend, driven by player demand, as stronger and stiffer fibers are produced and become cost effective and as lighter core materials that offer similar or improved mechanical properties also become available. The properties of longitudinal and torsional stiffness, breaking strength and wear resistance are all expressed comparatively for

state of the art circa 1997 technology.

	Weight	Stiffness (Axial and Torsional)	Breaking Strength	Wear Resistance
Ice Hockey	160-200 grams	High	High	Low
Off-ice Hockey	210-230 grams	Lower	Lower	High

Table 1 Comparison of Ice Hockey and Off-Ice Hockey Stick Blades.

This table identifies the performance window of opportunity that the present invention is designed to exploit. The ideal weight to achieve proper stick balance and maximal shot performance for both ice and off-ice hockey is currently in the 170 gram range. As stiffer stronger fibers are used in shafts and blades, this ideal weight will lower in proportion to the weight of the overall blade and shaft assembly. As long as the relative weight of the shaft and the blade are such that balance is maintained, and as long as the strength and stiffness of the blade are not compromised, lowering the weight of the blade will increase shot performance. The lowered weight results in a lower polar moment of inertia as the player flexes and swings the shaft resulting in more accurate shooting of the puck. Currently off-ice blades using either reinforced wood or ABS cored composite structures are considerably heavier than the high performance ice hockey blades as shown in the table.

Market experience reveals that off-ice hockey blades are sold with both stiffness and strength that are 30% lower than the typical high performance ice hockey blades. This is as a consequence of design compromises made to increase the wear resistance of the off-ice blades using current technology and lesser demands of the off-ice game i.e. lower puck weight and less shooting leverage.

SUMMARY OF THE INVENTION

The present invention overcomes the above shortcomings.

It is accordingly a primary objective of the present invention to provide a stick suitable for use in both ice hockey and off-ice hockey wherein the weight is in the lower range of the

best ice-hockey sticks, the stiffness is equal to or greater than the best fiber reinforced wood ice hockey blades and could approach that of the best composite blades, the wear resistance of the blade is equal to or greater than of the best ABS off-ice hockey blades and the breaking strength is equal to or greater than the best glass/wood ice hockey blades.

It was determined that no combination of existing technologies would meet these performance targets. Experimentation revealed that the use of a unique hybrid wear resistant polymer and foam core with weight reducing foam inserts allowed the target objectives to be met.

Thus the present invention is a composite blade for use with a hockey stick which is manufactured using a hybrid core consisting of a blade shaped piece of wear resistant polymer with structural foam inserts to decrease its weight and to increase the strength and stiffness of the blade when the composite skins are formed on the core. This hockey stick generally incorporates a wood, laminated wood or molded fiber reinforced wood hosel, although plastic or composite hosels can be used as well.

There is no innovation claimed with respect to the hosel except as regards the combination of it with the hybrid core into a composite blade which offers performance suitable for use in both ice hockey and off-ice hockey.

There is further no innovation claimed as to the use of fiber reinforced plastic on the faces of the blade, merely on the combination of the fiber reinforced resin skins with the hybrid polymer and foam core.

A major benefit of this invention is that the hosel is integrally joined to the composite blade and to the wear resistant light weight core under elevated temperature and pressure making a very strong bond in the area where over 44% of wooden stick failures occur. Various types of hosels can be successfully used in conjunction with the hybrid plastic and foam core including wood, fiber reinforced resin laminated wood or fiber reinforced resin molded wood, molded plastic or composite hosels.

The incorporation of a fiber reinforced resin layer between the hosels forward face and the core, and between the bottom of the hosel and the core, to strengthen the hosel to core

joint, is unique to this invention.

The concept of integrally molding a blade onto a reinforced shaft to form a one piece integral hockey stick is an already existing concept, however, the concept of using the hybrid core in the integrally molded blade is unique to the present invention.

In accordance with another object of the present invention there is provided a method of manufacturing a hockey blade comprising the following steps: a) making a core from wear resistant material; b) molding or machining at least one hole into said core; c) inserting and securing foam or other light weight inserts into said holes; d) assembling said resulting core with a hosel; e) covering said core and hosel combination with layers of fibrous materials; f) wetting said core and hosel combination with resin; and g) subjecting said core and hosel combination to heat and pressure, thereby molding a skin over said combination; whereby a hybrid wear resistant material/foam hockey blade is formed and adapted to be combined with a shaft to make a crossover hockey stick suitable for both ice and off-ice hockey.

In accordance with another object of the present invention there is provided a blade for a hockey stick comprising: a) a core of wear resistant material; b) at least one foam or other light weight insert; c) a hosel; and d) a fiber reinforced resin composite skin; whereby a hybrid wear resistant material/foam blade is adapted to be combined with a shaft to make a crossover hockey stick suitable for both ice and off-ice hockey.

In accordance with another object of the present invention there is provided a method for manufacturing a hockey blade comprising the following steps: a) making a core from wear resistant material; b) moulding or machining a weigh reduced core; c) assembling said resulting core with a hosel; d) covering said core and hosel combination with layers of fibrous materials; e) wetting said core and hosel combination with resin; and f) subjecting said core and hosel combination to heat and pressure, thereby moulding a skin over said combination; whereby a wear resistant blade is formed and adapted to be combined with a shaft to make a crossover hockey stick suitable for both ice and off-ice hockey.

In accordance with another object of the present invention there is provided a blade for a hockey stick comprising: a) a core of wear resistant material; b) at least one foam or other light weight insert; c) a hosel extending into a shaft; and d) a fiber reinforced resin composite layer;

whereby a wear resistant blade and its extension are adapted to make a crossover hockey stick suitable for both ice and off-ice hockey.

In accordance with another object of the present invention there is provided a blade for a hockey stick comprising: a) a weight reduced core of wear resistant material; b) a hosel; and c) a fiber reinforced resin composite layer; whereby a wear resistant blade is adapted to be combined with a shaft to make a crossover hockey stick suitable for both ice and off-ice hockey.

In accordance with yet another object of the present invention there is provided a blade for a hockey stick comprising: a) a weight reduced core of wear resistant material; b) a hosel extending into a shaft; and c) a fiber reinforced resin composite layer; whereby a wear resistant blade and its extension are adapted to make a crossover hockey stick suitable for both ice and off-ice hockey.

Further objects and advantages of the present invention will be apparent from the following description, reference being made to the accompanying drawings wherein preferred embodiments of the invention are clearly shown.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be further understood from the following description with reference to the drawings in which:

Figure 1 is a side view of a preferred embodiment of the invention;

Figure 2 is a side view of a series of four other possible configurations of ABS core and, in crosshatching, foam inserts that can be used as preferred embodiments;

Figure 3 is a longitudinal section through a preferred embodiment in accordance with the present invention;

DETAILED DESCRIPTION OF THE DRAWINGS

The preferred embodiment is the forming and bonding of a hosel of any construction, such as wood or laminated wood with possibly a molded layer of fiber reinforced resin applied to at least two of the longitudinal side surfaces or fiber reinforced wood or molded plastic or

fiber reinforced composite material, to a composite sandwich structure blade, as illustrated in Figure 1, which utilizes a hybrid core consisting of a blade shaped piece of wear resistant polymer core **1** into which light weight structural foam or other light weight inserts **2** are bonded along with any combination of fiber resin reinforcements in the skins that will provide the required strength, stiffness and weight of the blade making for a crossover blade suitable for both ice and off-ice hockey. As illustrated in Figure 2, the positioning of the foam inserts **2** can vary. Different hockey players require different weights and stiffnesses of stick and blade. Thus the choice of fiber architecture, that is fiber type, locations and orientations, will depend on the player's requirements. The process is suitable for use with a very wide range of core and fiber architectures.

It should also be noted that similar results could also be achieved by making the polymer core 1 thinner instead of having light weight inserts 2 bonded along. In this fashion, we end up with an equivalently light weight core which is highly durable and adapted to both ice and off-ice hockey.

Generally illustrated in Figure 3, the wear resistant polymer core **1** is made of acrylonitrile-butadiene-styrene (ABS). Precision fit inserts of 6 lb per cubic foot density thermoplastic polyurethane foam **2** are pressed into two irregularly shaped quadrilateral or trapezoid cavities. The foam inserts are completely contained within the perimeter of the ABS core **1** section, such that the ABS components and the two foam inserts together comprise a single hybrid core **7**. The hosel **3** is tapered and sized to fit the geometry of the hybrid core **7** such that the desired finished blade thickness is obtained. In this embodiment, one layer of spun glass rovings **4** is placed on the frontal face of the hosel **3** and the bottom end of the hosel where it will butt against the hybrid core **7**. The blade is attached to the shaft by several metal staples on each side. Stitched tri-axial (0°, graphite/glass hybrid, ±45° glass) graphite and glass material **5** is placed over both faces of the hybrid core **7** and curved to run along the hosel **3** to point **8** where the hosel **3** emerges from the hybrid core **7** outer skins and extends to toe **9** thereby encompassing the heel **10**. An additional layer of ∓45° glass is located over the hosel/blade joint area, generally **8**, to further increase strength.

This assembled preform of skins, hybrid core and hosel, is saturated with a carefully metered amount of toughened epoxy resin sufficient to fully wet the preform and yield a fiber loading of over 65% by volume when the skins have been consolidated and cured.

The fiber preform is placed into a curved mold shaped to yield the final morphology of the designed blade. The top half of the mold is closed and the shaft extends out of the mold and is supported by a fixture to ensure that the required geometrical orientation of the blade and shaft is maintained. The preform and shaft joint assembly are cured at 150° C and a molding pressure of between 350 and 800 psi, preferably 600 psi for 5 minutes. The part is removed and flash from the molding process is trimmed off and the required graphics applied.

The lower end of the hosel is reduced in section to a profile suitable for integration within the composite blade components. This profile can consist of a taper or of a taper terminating in a short reduced width section with generally rectangular shape. A glass roving can be attached to some or all of the faces of the hosel, and the bottom of the hosel, including the lower end face of the hosel. The glass rovings can be tacked in place by mechanical fasteners, such as staples, by a loop or loops of any suitable thread material or by small spots of hot melt thermoplastic adhesive, methacrylate type adhesive or any other suitable adhesive. The fastening method, whether adhesive or mechanical, is only used to locate the rovings prior to assembly and molding of the skins around the hosel and the hybrid plastic/foam core. The core is made from wear resistant plastic such as acrylonitrile-butadiene-styrene (ABS) or polyamide or polyimide or polystyrene or nylon and is molded, cut, machined or otherwise into the outline of a hockey stick blade, reduced in size to allow for the addition of composite outer skins to form the finished blade. One or more slots or holes of roughly ovoid or tetrahedral shape, with rounded corners, are molded or machined into the core, such that the entire thickness of the polymer core is removed over the area of the hole. The individual holes do not intersect with each other or with the outer perimeter of the lateral faces of the wear resistant polymer core. Foam inserts of the identical dimensions to these holes or slots are cut from a foam of a material selected to yield a high strength and high stiffness composite when covered with fiber reinforced resin skins.

The foam can be, but is not restricted to, any suitable thermoset or thermoplastic foam, with or without fiber or particulate reinforcements; any suitable syntactic foam with any type of honeycomb reinforcement where the honeycomb walls are oriented across the narrow dimension of the core. These foam inserts are placed in the appropriately sized holes in the plastic core to form the hybrid plastic and foam core of the blade. These foam inserts can be bonded or mechanically fastened into the core or they can be precision friction fitted. These foam inserts occupy at least 10% and no greater than 90% of the surface area and volume of

the wear resistant core. Any other light weight material such as honeycomb or balsa wood can be used in place of the foam.

The assembled hybrid core is attached to the lower end of the hosel by mechanical fasteners such as staples. It should be kept in mind that the hosel could be replaced by a full length hockey stick shaft suitably adapted to integrate with the hybrid core. The fasteners are only used to locate the hybrid core to the hosel during the subsequent manufacturing steps and do not constitute the mechanism by which the hosel is bonded to the core. The core and the hosel are covered with layers, also known as skins, of fibrous material such, but not restricted to, glass, graphite and aramid. These fibers can be in the form of mat, cloth or rovings. The reinforcement can be applied in the form of woven or stitched fabrics or of rovings or of expandable braided or woven socks in a primary or secondary operation. Fabric can be placed in several layers with fibers of the appropriate type for the loading found in use placed in suitable points of the laminate. For example, the lateral faces of the central part of the blade can be reinforced with two or more layers of glass or other fiber braid to improve the fracture resistance of this area which is used to strike the puck. One or more layers of unidirectional fibers or fabric, in particular ±45° fabric, can be used to reinforce the lateral sides at the point at which the shaft touches the core. Fibers, usually in the form of mat or braided socks can be wrapped around the entire blade assembly. The amount, type and orientation of fibers are selected to provide the desired weight, stiffness and strength of the blade and shaft assembly. The skins can alternatively be applied so that they do not extend to the very bottom, or other edges of the blade, such as the top, the heel and the toe, leaving the wear resistant polymer, such as ABS, core material exposed on at least the bottom of the blade. Alternatively, this wear resistant layer can be exposed when the skins are abraded by off-ice play.

The hybrid core and the hosel are wetted with a suitable resin, such as but not restricted to epoxy or a thermoplastic resin such as but not restricted to nylon. Alternatively, prepeg materials (fibrous materials pre-impregnated with resin and partially cured as purchased) can be used. This assembly is then subjected to carefully controlled heat and pressure to mold the skin of the blade into place integrally around the core and the hosel creating a strong bond of the skins to the core, the hosel and especially to the structural foam inserts in the core. Fixtures locate the hybrid core and the hosel to ensure the desired orientation of the two components as they are formed into the finished blade. The heat and

pressure can be applied by compression molding, resin transfer molding, resin injection molding or other processes. The blade can be laterally curved or otherwise reformed to any desired curvature typically used by hockey players. If the blade is assembled from a thermoplastic hybrid core and thermoplastic resin skins or from reformable thermoset resin, it can be molded into different curvatures by the application of heat and force or pressure subsequent to the initial final manufacturing process for the blade. For example, blades could be made without curves, with the retailer or end user hockey player curving the blades to their requirements.

This embodiment of the present invention provides a blade or stick suitable for use in both ice hockey and off-ice hockey. The weight of 175 grams is in the lower range of the best ice-hockey blades. The stiffness is equal to or greater than the best fiber reinforced wood ice hockey blades and approaches that of the best composite blades. The wear resistance of the blade is equal to or greater than of the best ABS off-ice hockey blades and the breaking strength is equal to or greater than the best glass/wood ice hockey blades.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes that come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

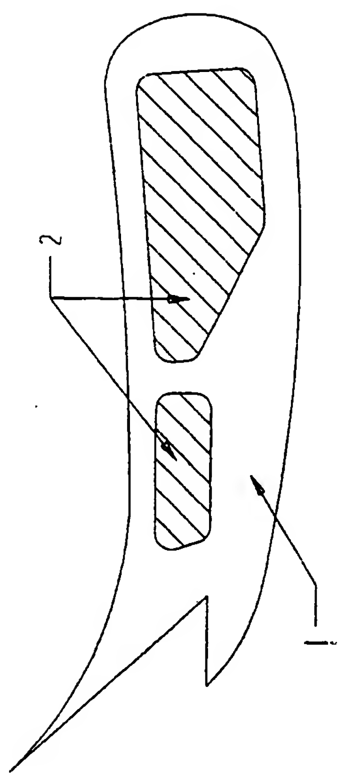


fig. 1

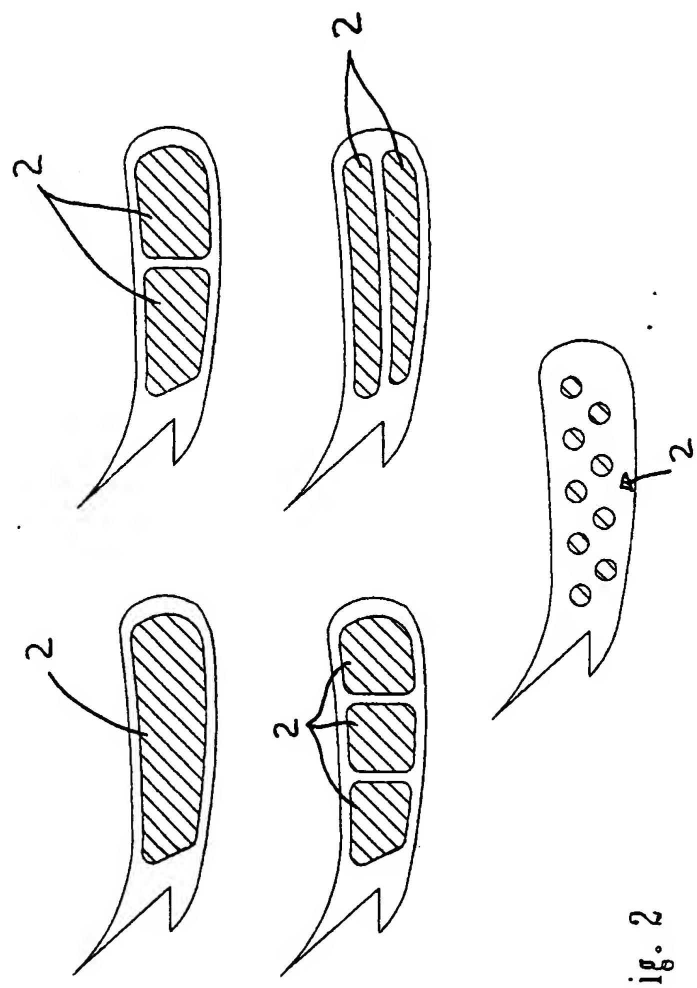


fig. 2

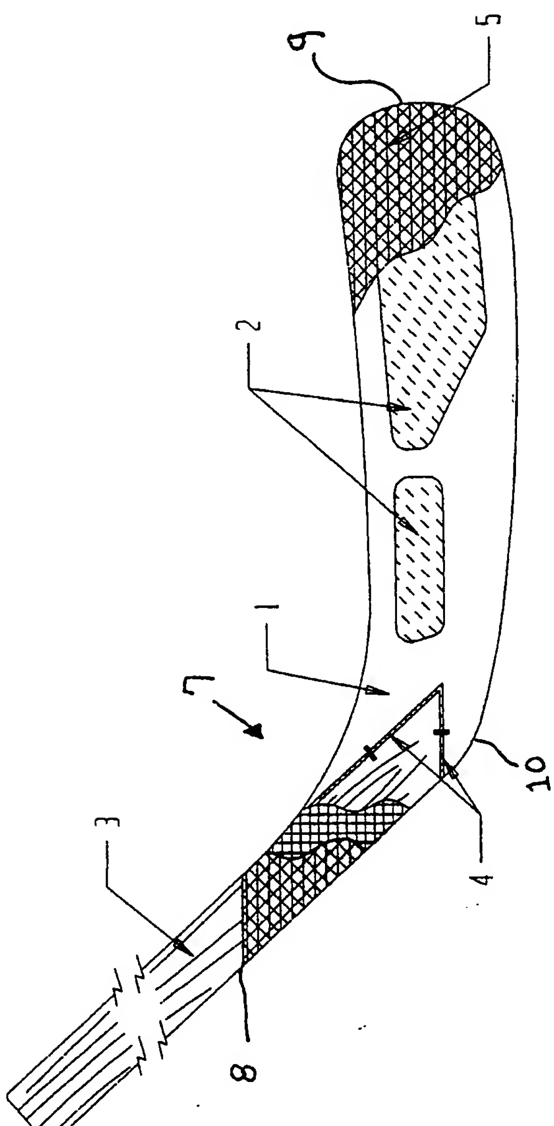
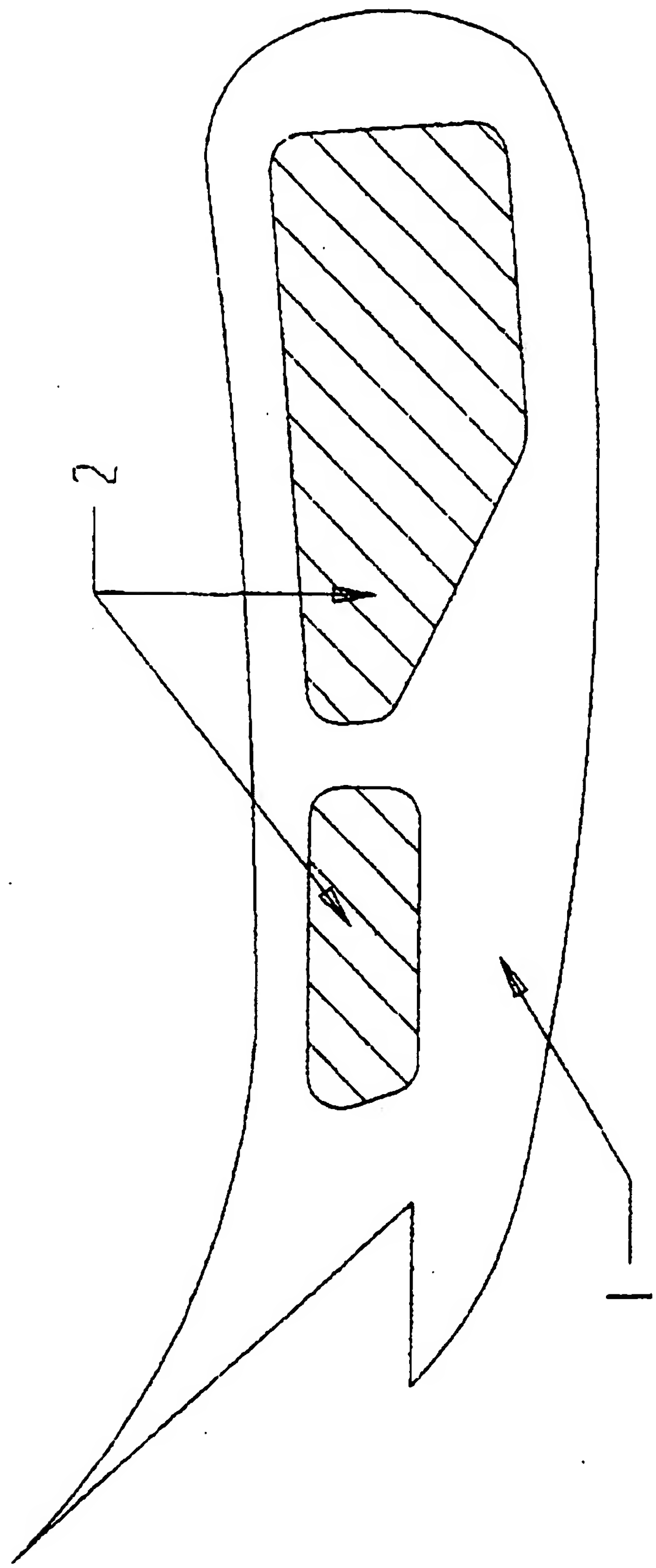


fig. 3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